Department of Computational Biology and Medical Sciences
Graduate Entrance Examination 2025 – Schedule B
Rationale for Question Design

Question 1
The Department of Computational Biology and Medical Sciences promotes research that integrates information science with life science. Because success in this interdisciplinary field requires knowledge of both areas, applicants are encouraged to study information science and biology prior to enrollment. Accordingly, the examination asks relatively fundamental questions from each discipline. The individual items were drawn from the sub-fields that had been published on the department website in advance.

Question 2
For the biochemistry section we devised questions that address (i) the fundamental chemical structures, reactions, and analytical techniques associated with key biomolecules—especially nucleic acids and proteins—and (ii) core principles governing macromolecular chemistry, exemplified by enzyme-kinetic analysis and nucleic-acid base pairing. Particular emphasis was placed on the examinee's ability to process a relatively large number of tasks both accurately and rapidly.

Question 3
Using microorganisms and humans as complementary case studies, we designed questions that probe a broad, multidimensional grasp of genetics. Particular emphasis is placed on (i) an integrated understanding of bacterial genome architecture and the molecular mechanisms that govern gene expression, and (ii) a conceptual understanding of genetic relationships within a pedigree, or to evaluate allele frequencies within a population based on Mendel's laws and Hardy-Weinberg principle.

Question 4
Focusing on core molecular-biology themes—gene-expression mechanisms and their regulatory systems—we prepared questions that test whether candidates (i) understand the underlying principles of key experimental techniques and (ii) can interpret experimental results logically. Emphasis is placed on an end-to-end reasoning ability: from designing experiments on *in vitro* mRNA synthesis or epigenetic regulation to analyzing and explaining the resulting data within a coherent molecular-biological framework.

Question 5
Drawing on developmental biology and regenerative/reproductive medicine, together with immunology and its medical applications, we prepared questions that range from fundamental life-science concepts to their deployment in modern medicine. The questions emphasize comprehensive knowledge and applied competence in (i) the mechanisms of embryonic development from the fertilized egg and their exploitation in regenerative medicine, and (ii) immune responses to infections and their therapeutic harnessing in immunotherapy.

Question 6
In the field of oncology, we asked questions to assess comprehensive knowledge, ranging from the basic characteristics, classification, and mechanisms of carcinogenesis, to clinical topics such as cancer treatment and epidemiology. We focused on comprehensive knowledge of cancer molecular biology, molecular understanding of cancer treatment, and the ability to interpret statistical analyses and graphs related to cancer.

Question 7
This question probes a foundational grasp of linear algebra. In this field, being able to carry out formal calculations is necessary but not sufficient—one must also understand the geometric meaning of those equations. Here, the key is to recognize that the given linear transformation represents a reflection across the plane whose normal vector is supplied. Applicants who see that geometric interpretation will find the questions straightforward.

Question 8
Many phenomena in the life sciences are fruitfully modeled as graphs. This problem checks that examinees (i) understand the elementary vocabulary of graph theory, and (ii) can apply basic graph algorithms together with their time-complexity analyses. The task also requires the ability to present a logical proof of a stated property.

Question 9
As life-science datasets grow, the parallelization of algorithms becomes ever more important. Effective parallel computation demands loops whose iterations have no mutual data dependencies. The question therefore asks examinees to construct a parallel radix-sort algorithm using only operations that can be executed independently. Because a parallel prefix-sum algorithm is somewhat intricate, it is provided as a black box, letting examinees focus on the design of the overall procedure.

Question 10
Biological processes are inherently stochastic, and therefore a deep command of probability and statistics is indispensable. To evaluate such mastery, the first part of the problem leads examinees through a basic derivation for the exponential distribution; the second part extends this to the distribution of the sum of independent exponentials (the Erlang distribution). The question is designed to assess foundational knowledge of probability theory and the ability to construct logical mathematical proofs.

Question 11
Dynamic programming is ubiquitous in bioinformatics, particularly in genomics. This question assesses if examinees understand how dynamic programming works:

- Part 1 focuses on pairwise sequence alignment with a linear gap score.
- Part 2 introduces an affine gap score.

Rather than merely recalling recurrence relations by rote, examinees must show they understand what each sub-expression represents, how individual states map to specific cells in the dynamic programming matrix, and how appropriate state decomposition leads to an efficient algorithm.